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Quality Control for the Operational Atmospheric Data Base

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Foreword

The operational atmospheric data base provides quality-controlled meteorological observations for use by the Navy's global and regional atmospheric prediction models and the stratospheric analysis. The atmospheric analyses and models produce numerical guidance and products in support of a wide range of Navy atmospheric and oceanographic requirements. Quality control of the meteorological observations is vital for identifying and eliminating erroneous observations that can adversely affect the quality of these operational products. This report describes the details concerning the operational implementation of the quality control system at the Fleet Numerical Oceanography Center. The quality control of meteorological observations is described in NOARL Report 26.

This document will be valuable for anyone who uses meteorological observations from the operational atmospheric data base. It will also be of interest to users of the data provided by the Naval Postgraduate School in support of the Tropical Cyclone Motion (TCM-90) experiment, since some of the observations were retrieved from the atmospheric data base.

The quality control procedures were initially developed in support of the Navy Operational Global Atmospheric Prediction System and in direct response to the validated Chief of Naval Operations requirements LANT MET 77-15 and OR 072-006-86. Because of the need for quality-controlled observations, other operational products now access the data base. All these products will continue to benefit from the ongoing development of the quality control system.

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Executive Summary

A new operational meteorological data base has been developed to provide quality-controlled observations for the atmospheric analysis and prediction systems at Fleet Numerical Oceanography Center. Quality control is a vital and necessary first step in atmospheric analysis and prediction, since erroneous observations can adversely impact the accuracy of these environmental products. The objective quality control procedures for the data base were developed by the Atmospheric Directorate of the Naval Oceanographic and Atmospheric Research Laboratory and are described in NOARL Report 26. This report focuses on the specific details pertaining to the local implementation of the quality control system. These include the treatment of multiple, nonidentical reports from the same station; errors introduced by data processing; bias corrections of radiosonde heights; and the subjective quality control of marine observations. This report provides the necessary information, such as the data base structure and data formats, required to use the operational atmospheric data base.

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The development and implementation of a successful, operational numerical prediction system requires continuous interaction between the researchers and those on the operational side. I acknowledge the following people for their assistance in the development and implementation of the quality control system: the late T. Hesse, FNOC; L. Clarke, B. Clune, J. Cornelius, and W. Thorpe, FNOC; B. Davies and H. Lewit, Computer Sciences Corporation; and E. Barker, R. Brody, J. Goerss, and T. Rosmond of NOARL.

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1.0 Introduction

A new, comprehensive meteorological data quality control (QC) system was installed with the new version of the Navy Operational Global Atmospheric Prediction System (NOGAPS 3.0) in early 1988. This system provides an operational atmospheric data base of quality-controlled observations on the Cyber 205 at the Fleet Numerical Oceanography Center (FNOC). The QC procedures and data base were specifically developed for use by the multi-variate optimum interpolation analyses (MVOI). The MVOI analysis is used by the global model (NOGAPS) and the regional and stratospheric analyses. Quality flags for the observations within a report are determined by quality checks made during the objective QC and NOGAPS analysis QC, and are stored along with the observation. After the NOGAPS MVOI has written the quality flags to the operational atmospheric data base, the quality-checked observations are transferred to a data base on the front-end computer for use by researchers and various applications programs.

The extensive data QC of the meteorological observations that is performed prior to the MVOI analysis is described in Baker (1991). This report emphasizes the elements of the system, such as data preprocessing and the data base structure, that are unique to its operational implementation at FNOC. All the details discussed here pertain to unclassified observations only. Appendices A and B contain the tables for the formats for the observations in the operational atmospheric data base.

2.0 Data Processing, Formats, and Data Base Structure

The global environmental observations are transmitted across the Global Telecommunications System (GTS) to users worldwide. The reports are retrieved from the GTS at Carswell Air Force Base, are reformatted, and are relayed to FNOC by way of the Automated Weather Network (AWN). Additional observations from the Global Weather Intercept Program are transmitted from Carswell Air Force Base on the AWN. The National Meteorological Center (NMC) also retrieves the global observation set from the GTS and transmits them to FNOC via a direct link between the two centers. The NMC-FNOC data link provides a backup should the AWN from Carswell Air Force Base be unavailable. Satellite temperature retrievals are transmitted directly from NMC/NESDIS (National Environmental Satellite Data and Information Service) to FNOC.

The raw observations are decoded and stored in packed-bit format in the FNOC operational files ADPFILE and SATFILE using the random access file manager, ZRANDIO. Each observation type is associated with a record name (Table 1). The same record names are maintained for the quality-checked data with one exception. The record name SOX is unique to the quality QC processing and refers to the entire integrated

Table 1. ADPFILE record identifiers according to observation type.

DATA TYPE	ADPFILE RECORD IDENTIFIER
RADIOSONDES (MANDATORY 100 mb AND BELOW)	SOM
RADIOSONDES (SIGNIFICANT BELOW 100 mb)	SOS
RADIOSONDES (MANDATORY ABOVE 100 mb)	SOU
PILOT BALLOONS (PIBAL)	PIB
SATELLITE SOUNDINGS (THICKNESS)	SOF
SATELLITE SOUNDINGS (TEMPERATURE, UP TO 50 mb)	SOG
SATELLITE SOUNDINGS (TEMPERATURE, ABOVE 50 mb)	SOH
SATELLITE CLOUD-TRACKED WINDS	TSX, TWX
AUSTRALIAN SEA-LEVEL PRESSURE BOGUS	PAB
MARINE (SYNOPTIC) OBSERVATIONS	SHX
LAND (SYNOPTIC) OBSERVATIONS	SMX
AVIATION HOURLIES (U.S. AND CANADA AIRWAYS)	SAX
METAR (INTERNATIONAL AIRWAYS)	MTR
AIRCRAFT REPORTS	SOA
RECONNAISSANCE AIRCRAFT REPORTS	SOB
SSM/I GEOPHYSICAL DATA RECORDS	SS5

radiosonde observation. The integrated sounding is made up of the lower (SOM) and upper (SOU) mandatory levels, and the lower (SOS) and upper (SOV) significant levels.

The preliminary processing occurs on the FNOC front-end computers. At the start of the operational run, the observation types used by the operational atmospheric analyses are unpacked, scaled to the proper physical units, and written out as ASCII records to a sequential file. The data formats used are essentially those agreed upon for the international exchange of meteorological observations during the First GARP* Global Experiment (FGGE) in 1979. Appendices A and B contain the subset of data formats applicable for the observations used by the FNOC operational atmospheric analysis and prediction systems. The code tables referred to in Appendix B are the standard World Meteorological Organization (WMO) code tables (WMO, 1988). The FGGE format (Anonymous, 1980) has been followed as closely as feasible; the only major exception is that a new format was defined for the DMSP SSM/I** geophysical observations.

*Global Atmospheric Research Program

**The Special Sensor Microwave Imagers are flown aboard the Defense Meteorological Satellite Program satellites.

The sequential file of observations in FGGE format is then transferred to the Cyber 205, where the actual QC of the observations is performed. The quality-controlled observations and the corresponding quality flags are written out in the FGGE format as CRANDIO records on the operational file, ADPFNOC. Each record is uniquely identified with an FNOC standard record label containing the observation type catalog name, date-time group, and record continuation indicator. The CRANDIO record names are the same as previously described and are shown in Table A.1, Appendix A. The record continuation indicator is the same as the "tau" indicator and is incremented for subsequent records of a given observation type with the same date and time. Individual reports are not allowed to cross the CRANDIO record boundaries. The radiosonde QC occasionally provides substitutions for erroneous values. The correction is integrated within the radiosonde report. The report header and the data line containing the original erroneous observation are written to the end of the same CRANDIO record. There must be at least one blank line between the last report on a record and any replaced original values. An example of a radiosonde report with corrections is shown in Figure 1. Further information on the ZRANDIO and CRANDIO file conventions may be found in the FNOC Computer User Guide (FNOC, 1974).

2.1 Observation Types

The observation types that are retrieved from ADPFILE, quality checked, and stored in the operational atmospheric data base are listed below. The numbers of observations were typical for a ±3-hour time window centered on 12 UTC in 1991. Reports continue to arrive for several hours after the observing time, so that the actual numbers vary some according to the cutoff time. The standard GTS data is supplemented by the Air Force Global Weather Intercept Program. Listening stations throughout the world intercept and retransmit weather reports, allowing for more timely data receipts, as well as more observations.

- Surface data, including land and ship synoptic reports, surface aviation observations (airways), and synthetic observations of sea-level pressure and/or wind.
  - Synoptic land (SMX): 14,000
  - Synoptic ship (SHX): 2,400
  - Airways (SAX): 3,600
  - Australian bogus (PAB): 900
- Conventional multilevel upper data.
  - Radiosondes/rawinsondes (S0X): 715
  - PIBALs (PIB): 425
- Aircraft reports.
  - Conventional aircraft observations (S0A): 1,300
  - Reconnaissance aircraft reports (S0B): 10
- Satellite cloud-tracked winds, temperature soundings, precipitable water profiles, and surface windspeed.
  - Thicknesses and precipitable water soundings (S0F): 6,400
  - Layer mean temperature and precipitable water (S0G): 3,600
  - Layer mean temperature, above 50 hPa (S0H): 3,700
  - Satellite cloud-tracked winds (TSX, TWX): 1,800
  - DMSP/SSMI sea surface windspeeds (SS5): 100,000

```
*1140375 771  2840  36609990110512  0  41
1010000     95  1-999  9-999  9-99-99  9   2
 1  9270   771  6  308  1  300  1-99-99  9   3
10  8500  1540  1  226  1  290  1-99-99  9   4
 2  8280  1760  6  204  1  268  1-99-99  9   5
10  7000  3180  1   76  1  160  1-99-99  9   6
 2  6540  3729  6   24  1  120  1-99-99  9   7
 2  6150  4223  6   -3  1  220  1-99-99  9   8
 2  6110  4275  6   -5  1  220  1-99-99  9   9
 2  5430  5203  6  -87  1  140  1-99-99  9  10
 2  5350  5318  6  -87  1  240  1-99-99  9  11
 2  5100  5687  6-101  1  180  1-99-99  9  12
10  5000  5850  1-105  1  220  1-99-99  9  13
 2  4860  6058  6-107  1  468  1-99-99  9  14
 2  4830  6106  6-107  1  308  1-99-99  9  15
 2  4680  6347  6-129  1  180  1-99-99  9  16
 2  4070  7397  6-199  1  348  1-99-99  9  17
10  4000  7530  1-207  1  340  1-99-99  9  18
 2  3350  8804  6-327  1  168  1-99-99  9  19
10  3000  9580  1-385  1  180  1-99-99  9  20
 2  279010065  6-433  1  128  1-99-99  9  21
10  250010810  1-455  1  220  1-99-99  9  22
 2  237011154  6-471  1  348  1-99-99  9  23
10  200012270  2-537  1  330  1-99-99  9  24
 2  158013750  6-611  1  308  1-99-99  9  25
10  15001081033-618  4  220  1-99-99  9  26
12  100016570  1-673  1  290  1-99-99  9  27
 2   76718128  6-719  1  280  1-99-99  9  28
10   70018690  1-725  1  270  1-99-99  9  29
 2   66318984  6-731  1  268  1-99-99  9  30
 2   56019998  6-629  1  300  1-99-99  9  31
10   50020710  1-619  1  300  1-99-99  9  32
 2   42021777  6-609  1  308  1-99-99  9  33
 2   35222887  6-563  1  320  1-99-99  9  34
 2   30223868  6-525  1-999  9-99-99  9  35
10   30023940  1-525  1-999  9-99-99  9  36
 2   23125605  6-509  1-999  9-99-99  9  37
10   20026590  1-473  1-999  9-99-99  9  38
 2   19526717  6-467  1-999  9-99-99  9  39
 2   10530864  6-419  1-999  9-99-99  9  40
10   10031220  1-999  9-999  9-99-99  9  41


*1140375 771  2840  36609990110512  0   2
10  150010810  5-455  3  220  0-99-99  9   2
```

Figure 1. Example of a radiosonde report that includes a correction followed by the original observation.

Observations are transmitted with the appropriate WMO block and station number. WMO block numbers are assigned according to broad geographical and political regions (Fig. 2). The station numbers are assigned according to latitude and longitude and generally increase from west to east and the first digit of the triple digit station number increases from north to south.

The United States and Canada follow the opposite convention. The procedure is slightly different for fixed and drifting buoys. The block number indicates the region of deployment as indicated in Figure 3. Members of the WMO who plan to disseminate buoy data on the GTS are assigned blocks of numbers; these numbers make up the station

2.2 The FNOC Master Station List

index. For drifting buoys, 500 is added to the assigned station index (WMO, 1988).

The block and station number must exist in the master station list for the observation to be decoded and stored in ADPFILE. For land stations, the station location and elevation are appended to the

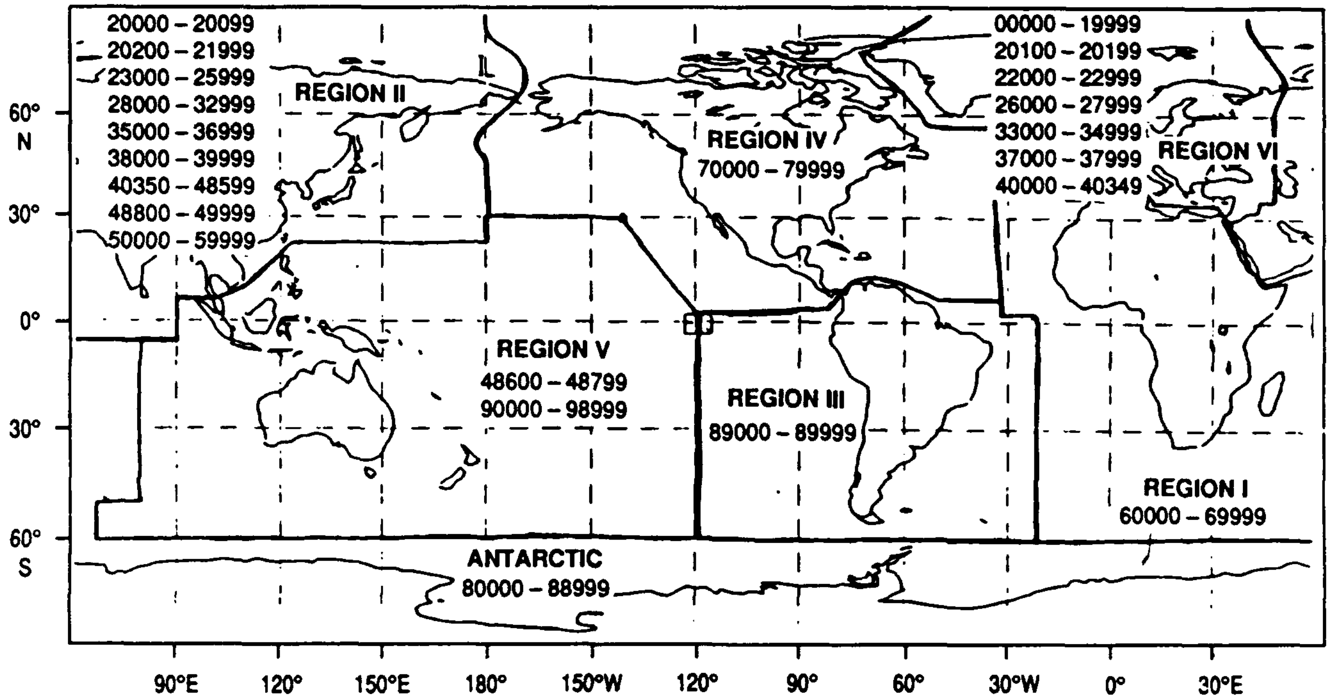

Figure 2. WMO regions and their associated block and station index numbers (after WMO (1990)).

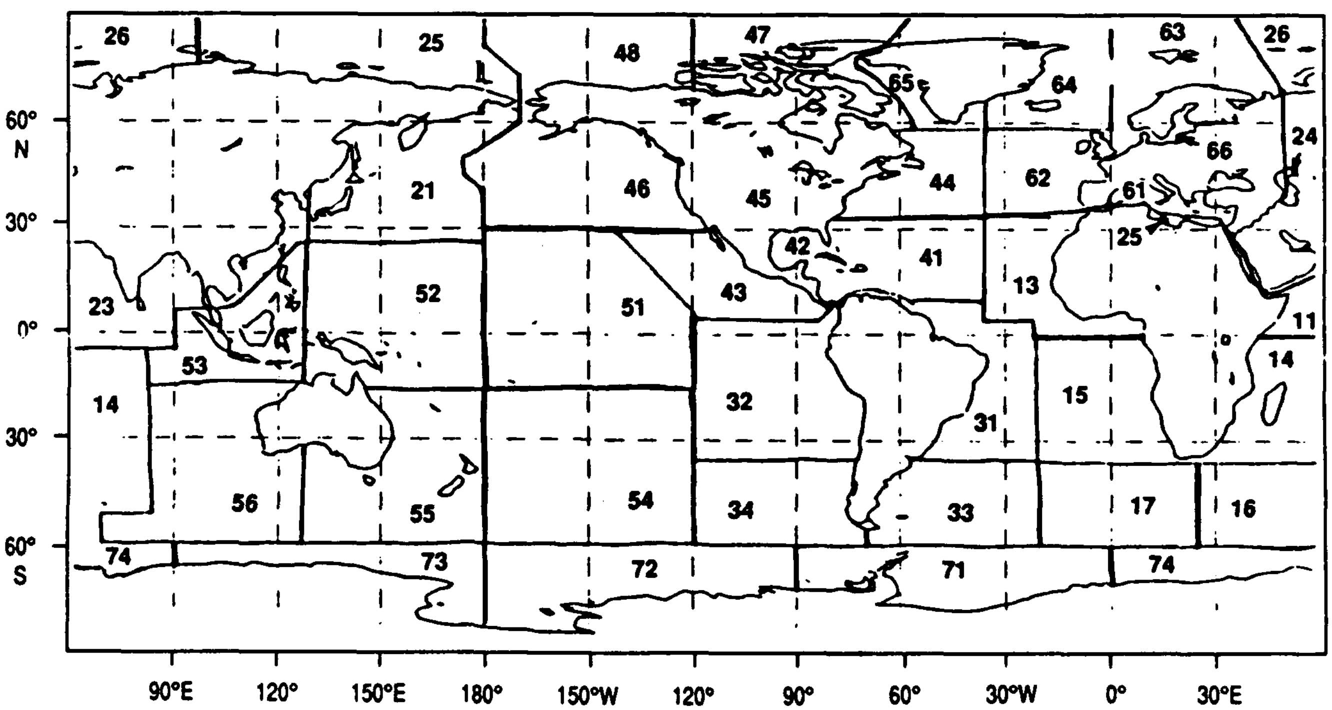

Figure 3. WMO regions and sub-areas in which marine observing platforms are deployed (after WMO (1988)).

observations, which are then decoded and stored in ADPFILE. The master station list used by FNOC is maintained by the Air Force at Carswell Air Force Base and is updated approximately every 2 weeks. The station locations or elevations in the master station list sometimes differ from those in the WMO station catalog (WMO, 1990), since station locations and elevations are not always known precisely and must be estimated from other sources of information. Occasionally, a station will have an erroneous station elevation or location. The problem of an incorrect station elevation is important for radiosonde QC because it invalidates a powerful quality check of the mandatory height data.

Users should be aware that the latitudes and longitudes stored with the observations in ADPFILE are in degrees and tenths, while both the FNOC master station list and the WMO station index (WMO, 1990) report station locations in degrees and minutes.

3.0 Quality Control

The QC for the operational atmospheric data base consists of four main components. The first component is the objective QC checks that are performed prior to the MVOI. Further quality checks are made within the MVOI. Several options are available for subjective intervention during the QC process. Finally, adaptive QC is used to provide estimates of station reliability and corrections for systematic observational errors.

The objective QC was patterned after that in use at the ECMWF (Norris, 1990) and is described in Baker (1991). All observations are checked for internal consistency and against climatological limits. The radiosondes and PIBALs undergo extensive vertical consistency checks. The quality control procedures within the analysis check the observation for consistency against the background field and with the adjacent observations. These procedures are described in Goerss and Phoebus (1991). The analysis quality flags in the operational atmospheric data base are set only by the NOGAPS MVOI.

The subjective QC performed at FNOC in support of the atmospheric analysis and prediction systems is restricted to the rejection or black-listing of marine observations. The sea-level pressure and/or winds for marine observations of pressure or wind may be rejected in two ways. The first requires the QC Duty Officer to specify the ship to be rejected. Any pressure or wind observation from that ship is rejected. No date and time are required with this option, so the blacklisted ship will be rejected as long as its name remains on the list. The second alternative allows the user to specify a latitude and a longitude, and windspeed and direction, or pressure, or both. This option also requires listing the date and time of the observation to be rejected. Any ships within 1° of the given location *and* within 1 hPa of pressure or 30° and 5 m/sec^{-1} for the wind will be rejected for that parameter.

This procedure has two main flaws. When the QC program is run in nonoperational mode, the current ship reject list is read and any ship whose name appears on the list will be rejected. The second flaw occurs during operational runs when more than one ship is within 1° of the indicated position and its observation falls within the allowed tolerances. Each ship rejected by this second method will generally reject a second, good observation with it.

An option to generate synthetic observations of sea-level pressure and wind bogus is available for NOGAPS (Goerss, 1988). It is intended to help the forecast model to better define rapidly deepening oceanic cyclones by providing additional observations over the data-sparse oceans. Based on satellite imagery analysis, the QC Duty Officer specifies the central pressure and position. Dynamically consistent synthetic observations are automatically generated, and a local MVOI analysis utilizing the synthetic observations is performed so that the impact of the synthetic observations may be evaluated and a final accept/reject decision made. Synthetic observations to help NOGAPS more accurately analyze and forecast tropical cyclones are generated automatically from the warnings issued by the Joint Typhoon Warning Center in Guam. The synthetic observations consist of a 1000-hPa height report and winds at the mandatory pressure levels up to 400 hPa.

3.1 Quality Flags

The quality checks set quality flags according to the severity of the error detected. Depending upon observation type, the flags may be set directly by a given test, or as the result of a series of tests. The quality flags differ slightly in meaning for the different observation types. The tables in Appendix A define the quality flags. The NOGAPS MVOI determines the analysis quality flags in the operational atmospheric data base. The single quality flag option determined by the MVOI is a "reject" flag, and it is set only for observations that have been considered and rejected by the analysis. Thus, observations that have a blank analysis quality flag may not have been considered by the analysis and may be incorrect.

3.2 Treatment of Duplicate Reports

Frequently, identical or nearly identical reports will arrive from the same station with the same observation time. FNOC receives the global set of all radiosonde, PIBAL and surface land and ship reports from both the NMC-FNOC data link and the AWN. Receiving data in this way automatically gives at least one duplicate. Exact duplicates are removed prior to storage in ADPFILE and the nearly identical reports by the QC system. The source of these nearly identical reports varies. They may be corrections for an earlier, incorrect observation, or they may be the same observation inserted onto the GTS at different nodes and slightly corrupted by transmission errors. The QC program attempts to determine which one of the nearly identical reports is most likely to be a correction or is most likely to be valid. A rigorous procedure has been implemented to handle these nearly identical reports for surface observations. Radiosondes also have this problem, but the decision-making algorithm is complicated by the need to evaluate each datum with the adjacent pressure level data. The selection algorithm for radiosondes will be implemented with the operational QC for meteorological observations on the next generation of computers. For surface observations, the nearly identical reports are handled by the following methods.

- All the nearly identical reports are quality checked.
- The first report is compared to the second according to this observation priority: pressure, wind direction, windspeed, temperature, dewpoint

depression, pressure tendency, and water temperature (for marine observations). The order was established according to MVOI analysis priority and restricted to observations that are quality checked and have quality flags associated with them. If an observation is accepted in one report but is rejected (or missing) in the other report, then the appropriate report is eliminated and the remaining one is compared with any other nearly identical reports.

• If no report has been selected after examining the seven priority observations, then the remaining nonchecked observations are examined for missing data. If the procedure encounters missing data within one report and not the other, then the report without the missing data is chosen.

• If no report has been chosen, then the last report is selected.

• If more nearly identical reports are available, then the procedure compares the current "best" observation with the next.

Typically, 10% of the ships have nearly identical duplicate reports; the average number of the nearly identical reports is 2. Approximately 6% of the land synoptic stations report nearly identical reports with an average number of nearly identical reports per station of 2.5. Only 3% of the airways stations transmit nearly identical reports, which invariably consist of the original report and (most likely) the retransmission of a corrected report.

3.3 Surface Data

The surface data types processed by the QC system are land and ship synoptic reports, surface aviation observations, and the Australian sea-level pressure synthetic observations (PAOBS). The PAOBS are used only in the posttime NOGAPS runs due to late data receipt. The international equivalent of the aviation hourlies are the METAR reports. A switch is available in the QC program to turn on processing of the MTR records. They are not currently used in the NOGAPS unclassified run.

All observations are checked against climatological limits (gross error checking) and also for internal consistency where applicable. The quality checks for surface data are described in Baker (1991). Specific details of the surface observations are discussed below. The quality checks here are very general and typically reject less than 1% of the observations.

The surface observations from the FNOC SMX, SHX, and SAX records do not store the "thousands" or "hundreds" digit of pressure or height. That is, a pressure of 1045.2 hPa will be stored at 452. This creates an ambiguity, as the above pressure could also be 945.2 hPa. Users should be aware of this and realize that two values or more are possible and that the correct one must be selected. For atmospheric data assimilation systems, the ambiguity is resolved in the analysis where both possible values are compared to the first guess, and the one closest to the first guess is accepted. Land stations that report station pressure are not checked by the objective QC because of this. In the analysis, the station elevation and standard atmosphere are used to calculate the station pressure and thus recover the leading digits. This value is then converted to a thickness and used at the nearest analysis pressure level.

The QC program reads the FNOC ship position continuity check file (SHPCOR) and applies the ship position changes and rejections. The reported position is compared with a region defined by extrapolation or interpolation along the track specified by previous observations. Ships that report a position outside this region may have either the position corrected or the ship position QC flag set to reject. The new position must resemble the position originally reported, i.e., 25.2°N, 130.0°E could be replaced with 25.2°N, 130.0°W.

Because of an error in the decoder for the SAX records, if the reported temperature is greater than or equal to 100°, the temperature is stored as missing. In addition, United States stations report the temperature in units of degrees Fahrenheit, while Canadian stations report the temperature in degrees Celsius. Since no straightforward method exists to differentiate these observations without using a background field, all observations are treated as being reported in degrees Fahrenheit and are converted to degrees Celsius. Both problems could adversely affect the MVOI analyses, since the temperatures are used to calculate the 1000-hPa heights that are used in the analysis.

All coastal and marine observations are grouped together in ADPFILE on the SHX record. The QC program uses the conventions for naming stations to distinguish between ships, fixed and drifting buoys, and C-MAN (coastal marine) stations. Each is assigned a unique identifier according to Table A.2 (App. A). A ship that reports zero speed is assigned a fixed ship identifier; otherwise, it is a mobile ship. FNOC translates the WMO five-digit block station number for drifting buoys into a five-character name where "A" corresponds to "0," "B" corresponds to "1," and so on. The permanent weather ships are no longer uniquely identified by the names "C7C," "C7M," etc. Instead, they now transmit the name of the actual ship taking the observations and are identifiable by location.

3.4 Aircraft Observations

Both conventional and reconnaissance aircraft data are processed by the QC program; however, only the conventional aircraft observations are used by NOGAPS. The preanalysis QC checks follow those outlined in Baker (1991) and involve checks against gross error limits and for consistency within the wind report. Aircraft observations tend to be clustered at certain latitude and longitude crossings over the oceans. This grouping gives a large amount of redundant information. The aircraft reports are combined into "super observations" within the analysis. The generation and use of the super observations in the analysis are discussed in Goerss and Phoebus (1991).

The reports with an identification number of "XX999" are either aircraft observations that arrived at Carswell without identification or pilot reports that are converted to the AIREP format at Carswell. The raw aircraft reports in ADPFILE do not carry information as to the type of original report, i.e., voice transmission versus keypad entry versus automated observing and relay systems. The quality of the data varies dramatically. Studies have indicated that typical rejection rates vary from greater than 30% for voice transmission reports to less than 1% for the fully automated system (Brewster et al., 1989).

3.5 Satellite Temperature and Moisture Retrievals

The TOVS soundings from the NOAA satellites[1] and the SSM/T[2] soundings from the Defense Meteorological Satellite Program (DMSP) satellites are both processed by the QC program. The header for each retrieval contains the satellite identification number as indicated in Table A.5 (App. A). These are the same satellite identifiers used by FNOC on ADPFILE and are subject to change when new satellites become operational and old ones fail.

The satellite soundings are generally in good condition with respect to gross errors or communication errors upon arrival at FNOC. FNOC receives satellite soundings from NESDIS via two different links. The S0F records arrive via Carswell Air Force Base and include layer thicknesses up to 1 hPa and precipitable water up to 300 hPa. The S0G and S0H records are transmitted directly from the NMC to FNOC and contain the soundings in terms of layer mean temperatures and precipitable water up to 50 hPa in the S0G record and from 50 to 0.4 hPa in the S0H records. The precipitable water is from the surface to 300 hPa. The DMSP instruments report up to 10 hPa only. The MVOI analysis uses the S0F records and assimilates the thicknesses directly, which alleviates the problem of assigning a base pressure to convert thicknesses to heights. The S0G records are redundant with the S0F retrievals and are processed only as a backup if the data link with Carswell is down. The quality and reliability of the S0F records appear to be better than those of the S0G records. Another advantage of the S0F records is that they contain the complete sounding up to 10 hPa (as required by the NOGAPS MVOI); use of the S0G records requires that they be co-located with the corresponding S0H retrieval for completeness.

The present ADPFILE format allows for the storage of one base pressure. However, the soundings are transmitted with two base pressures—one applicable for the thicknesses or temperatures and the other for precipitable water. ADPFILE stores the base pressure for thicknesses (temperatures). The base pressures are usually the same but are occasionally different. Using the thickness (temperature) base pressure typically gives an illogical structure (such as an 820 to 850 hPa thickness) and the entire sounding is flagged as "suspect."

Satellite temperature retrievals tend to have poor vertical resolution in the troposphere, and errors in the lower levels tend to be compensated for by errors of the opposite sign in the upper levels (Gallimore and Johnson, 1986). The analysis compares the lapse rate of the retrieval against that of the analysis background, and retrievals that deviate excessively from the background are eliminated. The errors in satellite retrievals also tend to be horizontally correlated, so the satellite retrievals do not undergo the same horizontal consistency checks as the other observations.

3.6 Satellite Cloud-Tracked Winds and Sea-Surface Winds

Satellite cloud-tracked winds from the geostationary satellite and DMSP/SSMI (Special Sensor Microwave Imagery) surface windspeeds over the oceans are processed by the QC program. The FNOC record

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[1] National Oceanic and Atmospheric Administration TIROS Operational Vertical Sounder

[2] Special Sensor Microwave Temperature

TSX contains the satellite cloud-tracked wind from Japan, the European Space Agency and, occasionally, a few from India. These latter observations are from 06 UTC and 18 UTC, arrive late, are few in number, and of poor quality. They probably never arrive in time to be used operationally in NOGAPS. The TWX records contain the NESDIS cloud-tracked winds from the U.S. GOES (Geo-stationary Operational Environment Satellite). Satellite cloud-tracked winds tend to increasingly underestimate the windspeed as the reported windspeed increases.

The SS5 geophysical data records contain sea surface windspeeds and various moisture parameters. The records are thinned by a factor of 6 during the preprocessing stage. This reduces the total number of windspeed observations for a ±3-hour time window to about 16,000. The SS5 geophysical data are quality controlled prior to storage in SATFILE. Any observations that fall outside reasonable limits are predefined by the original processing to be out-of-limits. Therefore, the only other QC performed on the SSM/I windspeeds is within the MVOI.

3.7 Conventional Multilevel Upper Air Data

This category includes the integrated radiosonde soundings (SOX) and PIBALs. Significant level winds are included in the sounding except where regional coding practices prevail, such as the United States, which transmits all the significant wind information in the PIBAL format. The WMO guide to regional coding practices (WMO, 1972) is a useful reference for these regional reporting differences.

The Taiwan radiosonde observations arrive twice with different block and station numbers, once with a Chinese block number, and once with a Taiwanese block number. The reports are generally not identical. For example, station 58968 is the same as station 46692, and station 59553 is the same as station 46747. Both reports are processed for each station.

The radiosondes are subjected to extensive vertical consistency checks. The vertical wind shear checks are also applied to the PIBALs. The procedure is documented in Baker (1991) and is briefly described here. After the soundings are checked for gross errors, the lapse rate check of the entire temperature profile (mandatory and significant) is performed. If an unreasonable lapse rate is detected, an attempt is made to isolate and flag the erroneous temperature. Next, the mandatory level data is recomputed from the adjacent significant levels if available. Erroneous mandatory level temperatures are replaced if possible; all other values are flagged as "suspect" if they fall outside the specified tolerances. During the next check, the geopotential heights are recomputed hydrostatically from the quality checked temperatures. Any report that differs from the recomputed value by more than the specified tolerance is flagged as suspect. This check can be a very powerful way to correct erroneous geopotential heights. However, an incorrect station elevation will result in faulty recomputed geopotential heights, and the reported heights will be flagged as suspect. Hydrostatic control of the standard level data is performed next, and erroneous heights or temperatures at mandatory levels are recomputed and replaced when possible. Finally, the vertical wind shear (both direction and speed) is checked.

The rawinsonde instruments in use by the United States and Canada are sensitive to solar radiation striking the thermistor. The subsequent

temperature errors lead to systematic errors in the calculated geopotential heights. Radiation bias corrections for these rawinsondes are determined and applied within the analysis. The original (not corrected) report is stored in ADPFNOC. The corrections are based upon the International Radiosonde Intercomparison Tests (Nash and Schmidlin, 1987), estimates of the observational biases, and solar elevation angle. The procedure for estimating the observational biases is described in more detail in section 4.1. The Chinese rawinsonde instrument has a marked bias that is corrected for within the MVOI as well. Corrections for other radiosonde instruments in use around the world are not yet made.

4.0 Monitoring of Observation Quality

The monitoring of observation quality is useful to detect systematic errors associated with observing stations or platforms (Böttger et al., 1987). Occasionally, the source of the error can be identified and corrected. Other times, the station must be blacklisted. The WMO has recently coordinated global efforts aimed at monitoring the meteorological observations available over the GTS. The lead forecasting centers currently responsible for this coordinated monitoring effort are listed:

- RMSC Bracknell for marine surface observations;
- RMSC ECMWF for radiosonde and pilot observations;
- WMC Washington for aircraft and satellite observations.

Every 6 months, the WMO (1990) produces a consolidated list of observing platforms believed to be of low quality. The ECMWF produces a monthly report of platform quality to facilitate the exchange of monitoring information. The list of suspect ships from the ECMWF report is used to update the FNOC ship blacklist. The National Buoy Data Center (NBDC, 1990) also publishes a monthly newsletter describing fixed and drifting buoy data availability and quality.

4.1 Bias Corrections for Radiosonde Heights

A 30-day history of the difference between the radiosonde wind and (bias corrected) geopotential height observations and analysis background field at all mandatory pressure levels for the 00 UTC and 12 UTC is maintained in ADPFNOC. Assuming that the systematic error is in the observations rather than in the analysis background field, the radiosonde biases and standard deviations may be calculated. Radiosonde stations tend to have distinctive bias signatures depending upon the country and instrument used. An example of the radiosonde geopotential height bias at 200 hPa for 12 UTC is shown in Figure 4. The number of reports for that 28-day period is shown in Figure 5. The Chinese radiosonde instrument displays a large, positive height bias. Just across the border, the radiosonde instrument in use in North and South Korea has a negative bias.

The standard method for determining radiosonde radiation corrections requires that the radiosonde instrument type be known. Radiation corrections are then calculated based upon the effects of long- and short-wave radiation on that particular sensor, as a function of solar elevation angle. The crux of these radiation corrections is to accurately determine (1) the type of instrument used by each station, and (2) whether radiation corrections were applied prior to transmission. The WMO publishes a list of radiosonde instruments in use and whether radiation

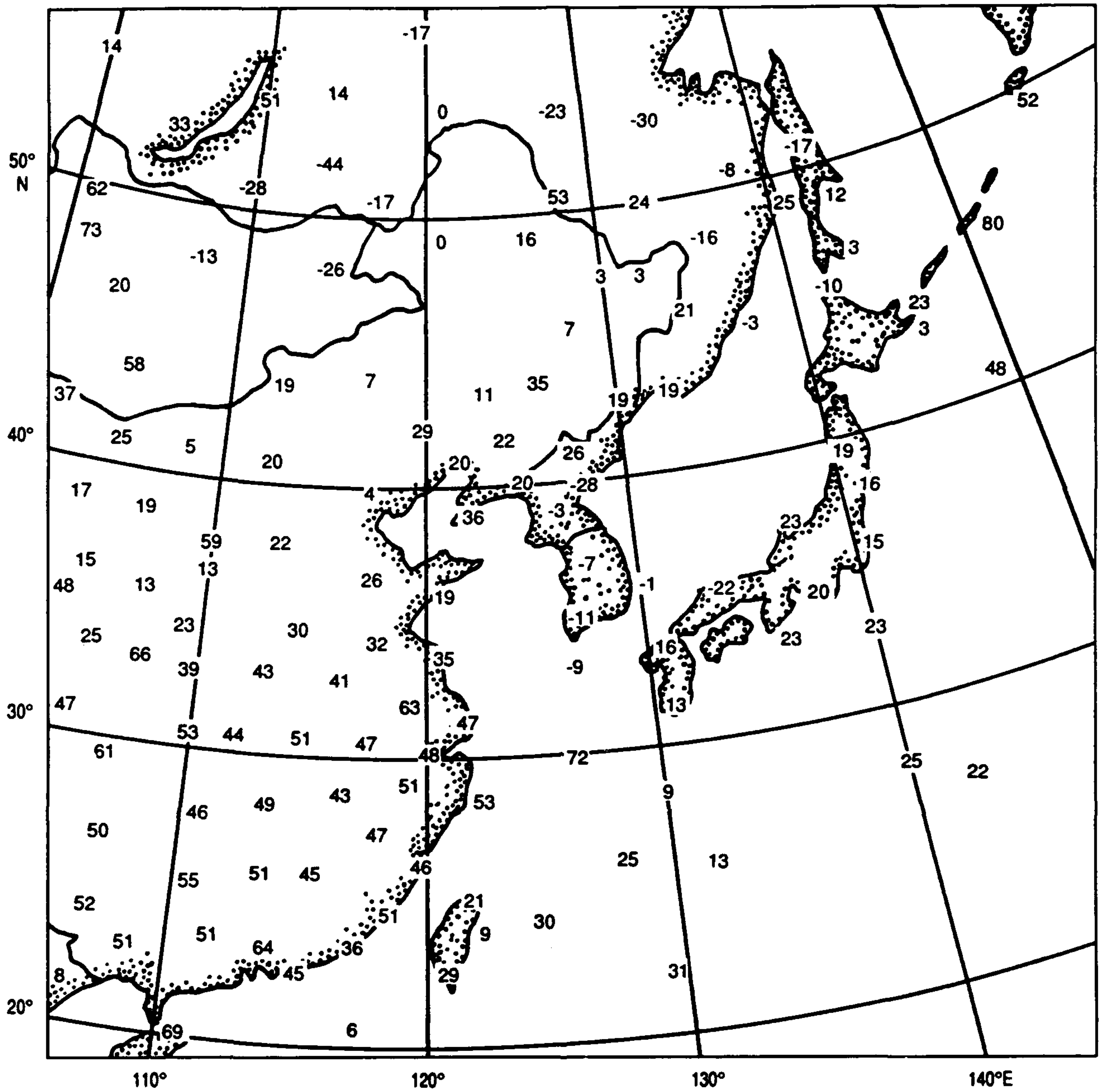

Figure 4. Radiosonde 200 mb geopotential height bias (observation minus analysis background). Data is from 12 UTC for the 28-day period up through September 21, 1988.

corrections are applied prior to transmission for stations in member countries (WMO, 1986). However, observing practices change and can be hard to determine. In the future, the archived radiosonde history file will be used to calculate the appropriate geopotential height bias (radiation) corrections for high-quality stations where the background field is reliable.

5.0 Summary

This report provided the details necessary to access and use the QC observations in the operational atmospheric data base. The data processing, formats, and data-base structure was discussed in section 2. The QC control procedures were briefly discussed in section 3. Working with

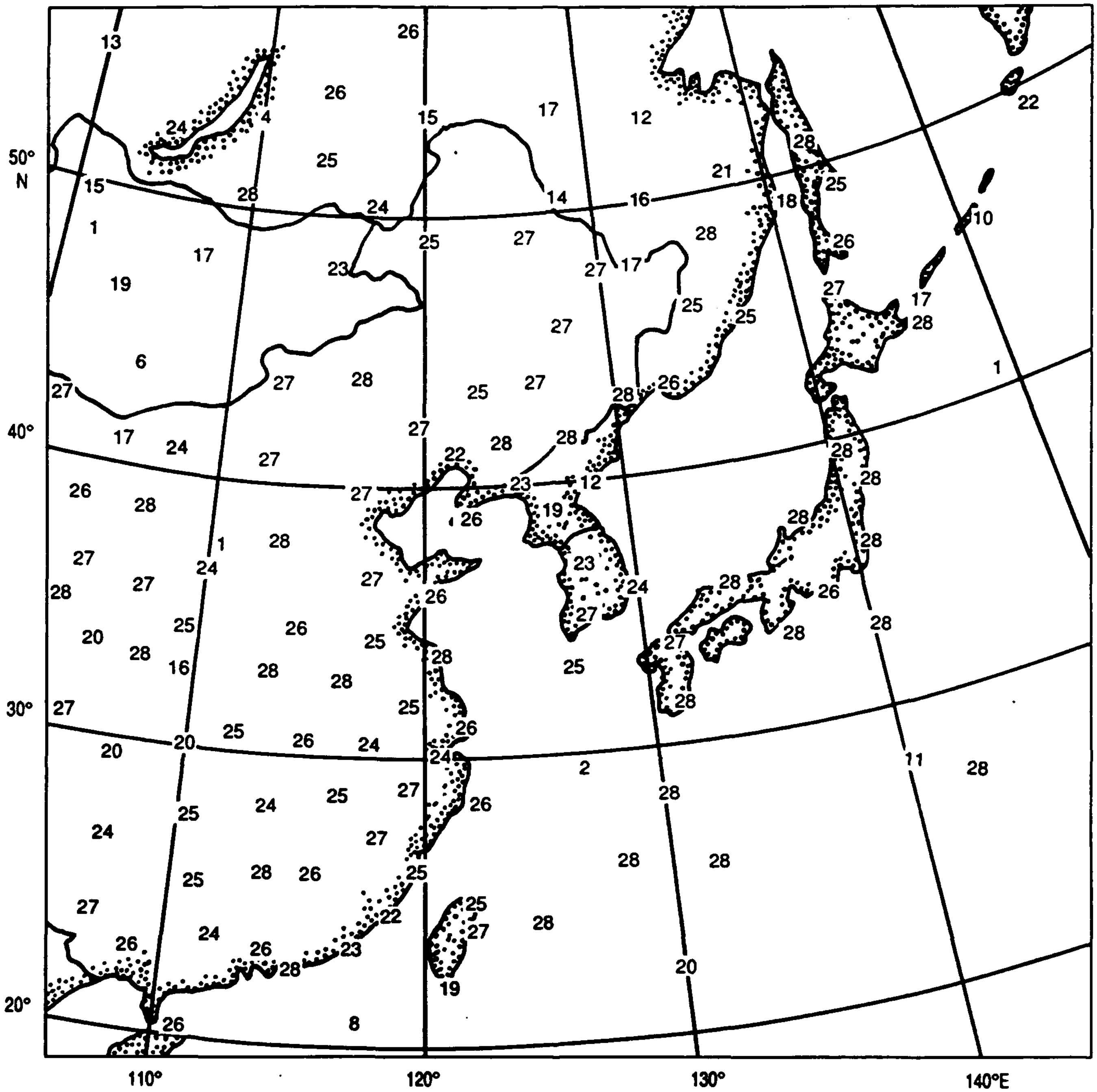

Figure 5. Same as Figure 1, except the numbers of reports used in computing the bias estimates are plotted.

raw observations always presents unforseen challenges and obstacles. Sometimes, the problems originate prior to arrival of the observations at FNOC. Others are introduced by the data processing at FNOC. Either way, they must be identified and handled prior to use by the operational products. The known problems and corrections (when feasible) for specific observation types were also discussed in section 3.

Frequently, the errors in meteorological observations are systematic. Many operational forecasting centers (including FNOC) routinely monitor data availability and quality. The use of these statistics for blacklisting

marine observations and correcting the inherent bias in radiosonde geopotential heights was presented in section 4.

6.0 References

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Appendix A

Tables of Codes

Data type	Record identifier	Format tables
Radiosondes	S0X	B.1,B.2
Pilot balloons	PIB	B.1,B.2
Satellite soundings (thickness)	S0F	B.11,B.12 B.13,B.14
Satellite soundings (temperature)	S0G, S0H	B.11,B.12 B.14,B.15
Satellite cloud-tracked winds	TSX, TWX	B.16,B.17
Marine (synoptic) observations	SHX	B.6,B.7 B.8,B.10
Land (synoptic) observations	SMX	B.6,B.7 B.8
Aviation hourlies (airways)	SAX	B.6,B.7 B.8
METAR (international airways)	MTR	B.6,B.7 B.8,B.9
Aircraft reports	S0A	B.3,B.4 B.5
Reconnaissance aircraft reports	S0B	B.3,B.4 B.5
SSM/I geophysical data records	SS5	B.16,B.17
Australian sea-level pressure bogus	PAB	B.6,B.7
FNOC marine synthetic observations	BOG	B.6,B.7
FNOC tropical cyclone synthetic obs.	GTO	B.1,B.2

Table A.1: Record identifiers and relevant format tables according to observation type.

Code figure	Description
11	Rawindsonde data
12	Pilot wind data
23	Aircraft data
31	Manual or automatic surface land observation
33	Surface observation from fixed ship or buoy
34	Surface observation from mobile ship or drifting buoy
35	Fixed buoy
36	FNOC sea level pressure and wind bogus
37	Australian sea level pressure bogus
38	Coastal marine (C-Man) data
39	Unidentifiable marine data type
41	Satellite sounding data
61	Satellite wind data
91	Experimental satellite sea surface wind speed data
98	Undeterminable data sources

Table A.2: Data Source Index

Code figure	Description
01	Surface level but not standard (pressure or height) level
02	Significant (non-standard pressure level) temperature or humidity
03	Tropopause but not at standard pressure level
04	Significant wind level not at standard (pressure or height) level
05	Maximum wind level not at standard (pressure or height) level
06	Significant temperature or humidity and wind, non-standard (p/H) level
10	Standard (pressure or height) level only
11	Surface level and standard (pressure or height) level
12	Significant temperature or humidity and standard pressure level
13	Tropopause level and standard pressure level
14	Significant wind level and standard (pressure or height) level
15	Maximum wind level and standard (pressure or height) level
16	Significant temperature or humidity and wind, standard (p/H) level

Table A.3: Type of level in upper-air data

Code figure	Description
0	Sea-level pressure
1	Station pressure
6	Geopotential of 850 mb
7	Geopotential of 700 mb
8	Geopotential of 500 mb
9	Unknown

Table A.4: Pressure code indicator

Code figure	Description
4	DMSP/SSMT F-10 for S0G and S0H
5	DMSP/SSMT F-11 for S0G and S0H
1	NOAA/TIROS/TOVS NOAA-11 for S0G and S0H
2	NOAA/TIROS/TOVS NOAA-12 for S0G and S0H
36	NOAA/TIROS/TOVS NOAA-11 for S0F
37	NOAA/TIROS/TOVS NOAA-12 for S0F
54	DMSP/SSMT F-10 for S0F
55	DMSP/SSMT F-11 for S0F
66	Unspecified geostationary satellite
99	Unknown

Table A.5: Instrument type for satellite derived observations

Code figure	Description
0	Processing technique not specified.
1	Clear path; automated statistical regression.
2	Partly cloudy path; automated statistical regression.
3	Cloudy path; automated statistical regression.
4	Clear path; automated statistical regression; interactive quality control.
5	Partly cloudy path; autoated statistical regression; interactive quality control.
6	Cloudy path; autoated statistical regression; interactive quality control.

Table A.6: Indicator figure for data processing technique used in SATEM code.

Code figure	Description
0	Miscellaneous SATEM information (required record)
1	Layer thickness between a reference pressure level and a standard isobaric surface (SATEM-Parts A and C)
2	Layer precipitable water between a reference pressure level and a standard isobaric surface (SATEM-Part A)
3	Layer mean temperature between a reference pressure level and a standard isobaric surface (SATEM-Parts B and D)

Table A.7: Type of satellite sounding level

IH Code	Description
blank	Value either not checked or found correct
3	Value found erroneous during horizontal control check
IV Code	**Description**
0	Vertical control check has not been made
1	Value found correct during vertical control check
2	Value found suspect during vertical control check
3	Value found erroneous during vertical control check
4	Observed value found erroneous during vertical control check; reconstituted value inserted
5	Vertical control check made - most likely value entered
6	Original value missing - reconstituted value inserted
7	Original value missing - value assigned
8	Value found erroneous during check against certain limits
9	Original value missing; no control check made
IL Code	**Description**
0	Checks against certain limits has not been made
1	Value found correct during check against certain limits
2	Value found suspect during check against certain limits
3	Value found erroneous during check against certain limits
4	Observed value found erroneous during check against certain limits; reconstituted value inserted
5	Check against certain limits made - most likely value entered
6	Original value missing - reconstituted value inserted
9	Original value missing; no control check made

Table A.8: Quality-control marks for upper air: horizontal checks (IH), vertical checks (IV) and checks against limits (IL)

Code figure	Description
0	Not checked
1	Observed value found correct during QC check
2	Observed value suspect
3	Observed value erroneous
4	Original value erroneous - substitution inserted (ship position only)
7	Value consistent with present and past observations (ship position only)
8	Value is not consistent with present and past observations (ship position only)
9	Observed value missing, no QC made

Table A.9: Quality-control indicators for surface land and marine reports.

Code figure	Description
0	Not specified
1	Low level of subjective confidence in observation
2	Medium level of subjective confidence in observation
3	High level of subjective confidence in observation

Table A.10: Subjective confidence factor

Code figure	Description
0	Quality control has not been made
1	The report was found correct during quality control
2	Suspect
3	Erroneous

Table A.11: Quality control indicator of satellite reports

Appendix B

Tables of Data Formats

Parameter	Number of characters	Position number	Units	Remarks
Unique report identifier	1	1		Unique character *
Data source index	2	2-3		See Table A.2
Block station number	5	4-8		
Elevation	4	9-12	meters	
Latitude	5	13-17	degrees and hundredths	North (+) South (-)
Longitude	5	18-22	degrees and hundredths	From 0.00 to 359.99
Instrument type	2	23-24		See Table A.5
Year	2	25-26		89 = 1989
Month	2	27-28		01-12 = January-December
Day	2	29-30		01-31
Hour	2	31-32		00-23 UTC
Minutes	2	33-34		00-59
Number of logical records	3	35-37		Variable number

Table B.1: Upper-air data format. Report identification record. Ship identifiers are stored in the 5 characters, left justified and blank filled if necessary. 'SHIP ' indicates that the name was unknown.

Parameter	Number of characters	Position number	Units	Remarks
Type of level	2	1-2		See Table A.3
Pressure	5	3-7	10^{-1} mb	
Height	5	8-12	gpm	
Quality Control: Height	2	13-14		See Table A.8
Temperature ,	4	15-18	10^{-1} °C	
Quality Control: Temperature	2	19-20		See Table A.8
Dew-point depression	4	21-24	10^{-1} °C	
QC: Dew-point depression	2	25-26		See Table A.8
Wind direction	3	27-29	degrees	
Wind speed	3	30-32	$\mathrm{m\,s^{-1}}$	
Quality Control: Wind	2	33-34		See Table A.8
Record number	3	35-37		Record number within report

Table B.2: Upper-air level data record

Parameter	Number of characters	Position number	Units	Remarks
Report identifier	1	1		Unique character *
Data source index	2	2-3		See Table A.2
Aircraft Identification	6	4-9		First 6 characters of aircraft ID
Type of wind	4	10		0 = doppler; 1 = fix-to-fix; 2 = other
Number of wind reports	2	11-12		
Latitude	5	13-17	degrees and hundredths	North (+) South (-)
Longitude	5	18-22	degrees and hundredths	From 0.00 to 359.99
Optional record indicator	1	23		0 = no;1 = yes
Type of quality check	1	24		0 = no QC check; 1 = horizontal QC done; 2 = QC limits check made
Year	2	25-26		89 = 1989
Month	2	27-28		01-12 = January-December
Day	2	29-30		01-31
Hour	2	31-32		00-23 UTC
Minutes	2	33-34		00-59
Number of logical records	3	35-37		Variable number

Table B.3: Aircraft format. Report identification record. The aircraft name is left-justified with unused characters blank-filled. 'AIRCFT' indicates the name is unknown.

Parameter	Number of characters	Position number	Units	Remarks
Pressure	4	1-4	mb	At flight altitude
Quality Control: Pressure	1	5		See Table A.8
Height	5	6-10	meters	Pressure altitude
Quality Control: Height	1	11		See Table A.8
Temperature	4	12-15	10^{-1} °C	At flight altitude
Quality Control: Temperature	1	16		See Table A.8
Not used	4	17-20		
D-value	5	21-25	meters	
Not used	4	26-34		
Record number	3	35-37		Record number within report

Table B.4: First aircraft data record (mandatory).

Parameter	Number of characters	Position number	Units	Remarks
Type of wind	2	1-2		0 = doppler; 1 = fix-to-fix; 2 = other
Latitude of wind	4	3-6	Degrees and tenths	
Longitude of wind	4	7-10	Degrees and tenths	
Direction of wind	3	11-13	Degrees true	
Speed of wind	3	14-16	$m\,s^{-1}$	
Quality Control: Wind	1	17		See Table A.8
Not used	17	18-34		
Record number	3	35-37		

Table B.5: Second aircraft data record (mandatory)

Parameter	Number of characters	Position number	Units	Remarks
Unique report identifier	1	1		Unique character *
Data source index	2	2-3		See Table A.2
Block station number	5	4-8		
Elevation	4	9-12	meters	
Latitude	5	13-17	degrees and hundredths	North (+) South (-)
Longitude	5	18-22	degrees and hundredths	From 0.00 to 359.99
Instrument type	2	23-24		See Table A.5
Year	2	25-26		89 = 1989
Month	2	27-28		01-12 = January-December
Day	2	29-30		01-31
Hour	2	31-32		00-23 UTC
Minutes	2	33-34		00-59
Number of logical records	3	35-37		Variable number

Table B.6: Surface land/marine format. Report identification record. The names are left-justified and blank filled if necessary. Unknown names are replaced with 'SHIP ' or 'BUOY ' as appropriate.

Parameter	Number of characters	Position number	Units	Remarks
Total cloud amount (N)	2	1-2	oktas	Code table 2700
Wind direction (dd)	3	3-5	degrees true	variable wind given as 990
Wind speed (ff)	3	6-8	$m\,s^{-1}$	
Quality Control: Wind	1	9		See Table A.9
Horizontal visibility (vv)	2	10-11		Code table 4377
Present weather (ww)	2	12-13		Code table 4677
Past weather (W)	2	14-15		Code table 4500
Pressure code indicator	1	16		See Table A.4
Sea-level or station pressure or geopotential height	5	17-21	10^{-1} mb or gpm	See Pressure Code Indicator
Quality Control: Pressure/height	1	22		See Table A.9
Air temperature	4	23-26	10^{-1} °C	
Quality Control: Air temperature	1	27		See Table A.9
Amount of C_L or C_M clouds (N_h)	2	28-29	oktas	Code table 2700
Clouds of genera Sc, St, Cu, Cb (C_L)	2	30-31		Code table 0513
Height of cloud base (h)	2	32-33		Code table 1600
Clouds of genera Ac, As, Ns (C_M)	2	34-35		Code table 0515
Clouds of genera Ci, Cs, Cc (C_H)	2	36-37		Code table 0509

Table B.7: First surface data record

Parameter	Number of characters	Position number	Units	Remarks
Dew point depression	3	1-3	10^{-1} °C	
QC: Dew point depression	1	4		See Table A.9
Not used	1	5		
Nature of pressure tendency (a)	2	6-7		Code table 0200
Magnitude of pressure tendency(ppp)	3	8-10	10^{-1} mb	
Quality Control: Pressure tendency	1	11		See Table A.9
Not used	26	12-37		

Table B.8: Second surface data record

Parameter	Number of characters	Position number	Units	Remarks
Significant cloud amount (N_s)	2	1-2	Oktas	Code table 2700
Significant cloud type (C)	2	3-4		Code table 0500
Significant cloud height (h_sh_s)	2	5-6		Code table 1677
Significant cloud amount (N_s)	2	7-8	Oktas	Code table 2700
Significant cloud type (C)	2	9-10		Code table 0500
Significant cloud height (h_sh_s)	2	11-12		Code table 1677
Significant cloud amount (N_s)	2	13-14	Oktas	Code table 2700
Significant cloud type (C)	2	15-16		Code table 0500
Significant cloud height (h_sh_s)	2	17-18		Code table 1677
Significant cloud amount (N_s)	2	19-20	Oktas	Code table 2700
Significant cloud type (C)	2	21-22		Code table 0500
Significant cloud height (h_sh_s)	2	23-24		Code table 1677
Not used	13	25-37		

Table B.9: Supplementary surface cloud-data record

Parameter	Number of characters	Position number	Units	Remarks
Period of wind waves	2	1-2	seconds	
Height of wind waves	2	3-4	0.5 m	
Direction of swell	2	5-6		Code table 0877
Period of swell	2	7-8	seconds	Code table 3155
Height of swell	2	9-10	0.5 m	
Not used	6	10-16		
Sea surface temperature	4	17-20	10^{-1} °C	
QC: Sea surface temperature	1	21		See Table A.9
Ship's course during past 3 hours	2	22-23		Code table 0700
Ship's average speed during past 3 hours	2	24-25		Code table 4451
Not used	6	26-31		
Quality Control: Ship position	1	32		See Table A.9
Not used	5	33-37		

Table B.10: Additional surface data record for marine report

Parameter	Number of characters	Position number	Units	Remarks
Report indicator	1	1		Unique character *
Data source index	2	2-3		See Table A.2
Not used	5	4-8		
Data processing indicator	2	9-10		See Table A.6
Not used	2	11-12		
Latitude	5	13-17	degrees and hundredths	North (+) South (-)
Longitude	5	18-22	degrees and hundredths	From 0.00 to 359.99
Instrument type	2	23-24		See Table A.5
Year	2	25-26		89 = 1989
Month	2	27-28		01-12 = January-December
Day	2	29-30		01-31
Hour	2	31-32		00-23 UTC
Minutes	2	33-34		00-59
Number of logical records	3	35-37		Variable number

Table B.11: Satellite sounding format. Report identification record.

Parameter	Number of characters	Position number	Units	Remarks
Type of level	2	1-2	Code figure = 0	See Table A.7
Not used	22	3-24		
Number of reported thickness layers	2	25-26		From SATEM Parts A and C
Number of reported precipitable water layers	2	27-28		From SATEM Part A
Number of reported mean temperature layers	2	29-30		From SATEM Parts B and D
Not used	3	31-33		
Quality control flag	1	34		See Table A.11
Logical record number	3	35-37		Record number within report

Table B.12: Miscellaneous satellite sounding data (always second record within satellite sounding observation).

Parameter	Number of characters	Position number	Units	Remarks
Type of level	2	1-2	Code figure = 1	See Table A.7
Objective thickness quality indicator	2	3-4	percent	
Pressure at reference level	5	5-9	10^{-1} mb	base or standard pressure
Standard level pressure	5	10-14	10^{-1} mb	
Layer thickness	4	15-18	tens of gpm	
Objective thickness quality indicator	2	19-20	percent	
Standard level pressure	5	21-25	10^{-1} mb	
Standard level pressure	5	26-30	10^{-1} mb	
Layer thickness	4	31-34	tens of gpm	
Logical record number	3	35-37		Within satellite sounding report

Table B.13: Optional record for satellite sounding thickness data (SATEM Code Parts A and C).

Parameter	Number of characters	Position number	Units	Remarks
Type of level	2	1-2	Code figure = 2	See Table A.7
Index of accuracy for precipitable water	2	3-4	percent	percent of derived value
Pressure at reference level	5	5-9	10^{-1} mb	base or standard pressure
Standard level pressure	5	10-14	10^{-1} mb	
Layer precipitable water	4	15-18	mm	
Index of accuracy for precipitable water	2	19-20	percent	
Standard level pressure	5	21-25	10^{-1} mb	
Standard level pressure	5	26-30	10^{-1} mb	
Layer precipitable water	4	31-34	mm	
Logical record number	3	35-37		Within satellite sounding report

Table B.14: Optional record for satellite sounding precipitable water data (SATEM Code Parts A).

Parameter	Number of characters	Position number	Units	Remarks
Type of level	2	1-2	Code figure = 3	See Table A.7
Objective mean temperature quality indicator	2	3-4	percent	
Pressure at reference level	5	5-9	10^{-1} mb	base or standard pressure
Standard level pressure	5	10-14	10^{-1} mb	
Layer mean temperature	4	15-18	10^{-1} °C	
Objective mean temperature quality indicator	2	19-20	percent	
Standard level pressure	5	21-25	10^{-1} mb	
Standard level pressure	5	26-30	10^{-1} mb	
Layer mean temperature	4	31-34	10^{-1} °C	
Logical record number	3	35-37		Within satellite sounding report

Table B.15: Optional record for satellite sounding temperature data(SATEM Code Parts A and C).

Parameter	Number of characters	Position number	Units	Remarks
Report indicator	1	1		Unique character *
Data source index	2	2-3		See Table A.2
Data processing method used	2	4-5		Code figure = 05 for SSM/I
Not used	17	6-22		
Instrument type	2	23-24		See Table A.5
Year	2	25-26		89 = 1989
Month	2	27-28		01-12 = January-December
Day	2	29-30		01-31
Hour	2	31-32		00-23 UTC
Minutes	2	33-34		00-59
Number of logical records	3	35-37		Variable number

Table B.16: Satellite cloud tracked winds and SSM/I wind speeds. Report identification record.

Parameter	Number of characters	Position number	Units	Remarks
Latitude	4	1-4	degrees and tenths	North (+) South (-)
Longitude	4	5-8	degrees and tenths	From 0.00 to 359.99
Unused	2	9-10		
Pressure	3	11-13	mb	At effective wind level
Subjective pressure confidence factor	1	14		See Table A.10
Objective QC flag	1	15		See Table A.11
Temperature	3	16-18	10^{-1} °C	
Wind direction	3	19-21	degrees true	
Wind speed	3	22-24	$m\,s^{-1}$	
Not used	13	25-37		

Table B.17: Record for wind and temperature data

Parameter	Number of characters	Position number	Units	Remarks
Hour	2	1-2		00-23 UTC
Minute	2	3-4		00-59
Latitude	4	5-8	degrees and tenths	North (+) South (-)
Longitude	4	9-12	degrees and tenths	From 0.00 to 359.9
Wind speed	4	13-16	tenths	
Quality control: Wind speed	2	17-18		
Rain rate	2	19-20		
Water vapor over ocean	3	21-23		
Soil moisture	2	24-25		
Cloud water	3	26-28		
Surface type	1	29		0=land; 3=ice; 5=ocean; 6=coast; 9=unknown
Rain flag	2	30-31		0(< 2); 1(2-4); 2(5-10); 3(> 10) ms^{-1}
Satellite ID	2	32-33		8=F-8; 10=F-10; 11=F-11
Record number	3	34-36		Record number within report

Table B.18: Record for SSM/I wind speeds over oceans.

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A new operational meteorological data base has been developed to provide quality-controlled observations for the atmospheric analysis and prediction systems at Fleet Numerical Oceanography Center. Quality control is a vital and necessary first step in atmospheric analysis and prediction, since erroneous observations can adversely impact the accuracy of these environmental products. The objective quality control procedures for the data base were developed by the Atmospheric Directorate of the Naval Oceanographic and Atmospheric Research Laboratory and are described in NOARL Report 26. This report focuses on the specific details pertaining to the local implementation of the quality control system. These include the treatment of multiple, nonidentical reports from the same station; errors introduced by data processing; bias corrections of radiosonde heights; and the subjective quality control of marine observations. This report provides the necessary information, such as the data base structure and data formats, required to use the operational atmospheric data base.

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